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PHLEBOTOMUS SAND FLIES OF MALAYA AND BORNEO

(Diptera: Psychodidae)

By Laurence W. Quate[1] and G. B. Fairchild[2]

During field work by one of us (L. W. Q.) in Malaya and British North Borneo in 1958–59 special attention was paid to the collecting of *Phlebotomus*. The work has resulted in recording the genus from Borneo for the first time and finding a number of new species in the Indo-Malayan region. Contrary to Causey's observation (1938), sand flies are fairly numerous in Malaya as well as Borneo. Many more species will certainly be found, for most of the species treated herein were taken only during a three-month period in a few localities and, furthermore, we have in our collection a number of new species that are not being described because of inadequate series.

The field work was financed from a research grant of the National Institutes of Health (Grant E-1723) supporting the B. P. Bishop Museum project, "South Pacific Insects of Public Health Importance." Some additional material was received from the Institute of Medical Research, Kuala Lumpur, Malaya through the courtesy of Dr. J. A. Reid and from Dr. H. E. McClure, U. S. Army Medical Research Unit, Kuala Lumpur.

Gratitude is expressed to the following for assistance rendered during the field work: Mr. J. K. Cox, Dept. of Agriculture, Jesselton, North Borneo; Mr. George Carson, Conservator of Forests, Forestry Dept., Sandakan, North Borneo; Mr. S. A. Cope, Bombay Burmah Timber Co., Tawau, North Borneo; Lt. Col. Robert Traub, formerly Commanding Officer, U. S. Army Medical Research Unit, Kuala Lumpur, Malaya and Dr. John Hendrickson, University of Malaya, Kuala Lumpur. We are indebted to Mrs. Stella M. Quate for many of the illustrations.

The localities at which sand flies were collected are as follow:

Ranau, North Borneo: About 70 kilometers inland from Jesselton at the southeast base of Mt. Kinabalu. This is a village in a fertile valley at an elevation of 530 meters. Specimens were collected in secondary forest in hollow trees and tree buttresses.

Tawau, North Borneo: A small town on the east coast. Specimens were collected

1. B. P. Bishop Museum, Honolulu, Hawaii.
2. Gorgas Memorial Laboratory, Panama, Republic of Panama.

at dusk by continuous sweeping of the insect net back and forth without touching vegetation while walking along the beach. The sandy beach was bordered by buildings and lawns.

Kalabakan, North Borneo: About 50 kilometers upriver from Tawau in the southeast corner of North Borneo at sea level. Lumbering operations were being carried out by the Bombay Burmah Timber Co. Collecting was done chiefly in a primary, undisturbed dipterocarp forest and specimens were found in hollow trees and tree buttresses.

Gomantong Caves, North Borneo: Caves in a limestone ridge near sea level about 30 kilometers south of Sandakan surrounded by primary dipterocarp forest. Large populations of swiftlets and bats occupy the caverns. The main chamber is huge with the ceiling over 30 meters high and a number of smaller chambers lead off from it. Specimens were collected in the smaller caves where it was possible to reach the ceiling.

Gua 'Che Yatim, Pahang, Malaya: Caves in limestone hills in the King George V National Park in eastern Malaya. A number of small caves with ceilings two to ten meters high. Several species of bats occupied the caves in which *Phlebotomus* were collected.

Batu Caves, Malaya: Several large caves in a limestone ridge near Kuala Lumpur. This is a popular sightseeing spot visited by many people, and the original biota has been much disturbed. A number of arthropods inhabit the caverns and bats nest in the less disturbed inner recesses. *Phlebotomus* sand flies were collected during an ecological study by Dr. H. E. McClure and were made available to us for study.

The terminology is the same as used by recent students of *Phlebotomus* and is described by Fairchild and Hertig (1947) and Kirk and Lewis (1951). In addition to the taxonomic characters discussed by these authors, the ratio of the femur, tibia and basitarsus of at least the middle leg has been included in the descriptions as it showed variation among the species we studied.

Types of the new species will be deposited at the B. P. Bishop Museum (BISHOP). Paratypes, as far as possible, will be deposited at the U. S. National Museum (USNM) and British Museum (Natural History) (BMNH).

KEY TO SPECIES OF PHLEBOTOMUS IN MALAYA AND BORNEO

1. Abdominal hairs erect (if hairs absent, sockets as large on tergites 2 to 6 as on 1). Male style with 3 or 5 spines 2
   Abdominal hairs on tergites 2 to 6 recumbent (may be few erect hairs on tergites 2 to 6 of *squamipleuris*). Style with 4 major spines and supplementary seta..... subgenus *Sergentomyia*..... 5

2 (1). Antennal segments 3 three or more times length of proboscis and greatly exceeding short palpus; pharynx unarmed; palpal formula 1–2–4–5–3. Male style very long, with 3 major spines; pair of internal sclerotized rods associated with genital pump. Female spermatheca with short, wide ducts ....subgenus *Idiophlebotomus*..... 3
   Antennal segment 3 subequal to or shorter than proboscis, always shorter than palpus; pharynx armed with apical cluster of spines; palpal formula 1–4–2–3–5 or 1–4–2–5–3. Male genitalia with no sclerotized rods. Spermatheca small with long ducts..... subgenus *Phlebotomus* 4

3 (2). Male style with row of 5 stiff hairs at base of proximal spine; aedeagus hook-

ed at tip. Female cibarium with pair of lateral, triangular plates on ventral surface bearing scattered vertical teeth and with serrate rod-like thickening between plates. Spermatheca globular (mounted specimens may have spermatheca shrunken and appearing similar to that of *pholetor*, see fig. 1e). Malaya ..... **asperulus**

Male style with 2 stiff hairs near base of proximal major spine; aedeagus clubbed. Female without pair of triangular plates on cibarium. Spermatheca cylindrical, faintly wrinkled, ducts very short, opening separately into vagina. Borneo ..... **pholetor**

4 (2). Antennal segment 3 extending to about tip of proboscis; cibarium with trapezoidal pigment patch. Male style with 4 spines, 2 apical, 2 basal..... **stantoni**

Antennal segment 3 much shorter than proboscis; no pigment patch; cibarium armed with few, scattered teeth. Male style with 5 spines, 2 apical and 3 median. Spermatheca strongly annulate..... **argentipes**

5 (1). Tufts of broad scales on pleuron; Newstead's scales on palpal segments 2 and 3. ..... **squamipleuris indica**

Pleuron without scales; Newstead's scales on palpal segment 3 only or absent... 6

6 (5). Males 7

Females 13

7 (6). Style with at least 1 spine near middle of segment; coxite with basal patch of setae on inner face 8

Style otherwise..... 10

8 (7). Style short and stout, 1 spine at middle, 2 apical and 1 midway between, seta proximal to most basal spine. Alpha subequal to beta, delta about 1/2 alpha; mesonotum and pleuron not strongly infuscated. Borneo..... **displicatus**

Style long and slender, spines in 2 paired groups with seta between them 9

9 (8). Lateral lobe about 1/2 length of coxite, but slightly longer than paramere; coxite with basal tuft small and compact, of short setae, and with apical patch of longer hairs on inner face; genital filaments at least 3 × length of pump. Palpal formula 1–2–3–4–5; antennal segment 3 very long, 2 × length of proboscis; alpha subequal to beta, delta more than 1/2 alpha; mesonotum and pleuron lightly infuscated ..... sp. near **sylvestris**

Lateral lobe longer, about 2/3 length of coxite, clearly longer than paramere; basal tuft of coxite more diffuse and of longer setae, apical tuft less compact; genital filaments not over 2 × length of pump. Palpal formula 1–2–4–3–5; antennal segment 3 shorter, though exceeding proboscis; alpha shorter than beta, delta less than 1/2 alpha; mesonotum and pleuron strongly infuscated. Malaya..... **whartoni**

10 (7). Style with all spines closely crowded at apex; coxite without group of setae on inner face at base. Alpha shorter than beta; delta less than 1/3 alpha, often negative; antennal segment 3 shorter than proboscis. Genital filaments about 3 × length of pump. Pharynx spinose at apex. Borneo ..... **brevinervis**

Style with 1 or 2 subterminal spines; coxite often with a group or patch of setae on inner base..... 11

11 (10). Alpha markedly shorter than beta or gamma; delta 1/3 to 1/2 alpha; cibarium without teeth; palpal formula 1–2–3–4–5. Style with 2 terminal and

2 subterminal spines, seta little basad of proximal spine. Malaya ..... **anodontis**

Alpha markedly longer than, or subequal to, beta or gamma; delta more than 1/2 alpha 12

12 (11). Seta of style distad to most basal spine. Mesonotum and lower 1/2 of pleuron strongly infuscated, coxae and upper part of pleuron pale; cibarium with a curved comb of about 20, fine vertical teeth. Borneo ..... **denticulatus**

Seta of style little basad of proximal spine. Median stripe of mesonotum, lower part of pleuron, coxae and genitalia brown; cibarium with row of 12 to 15 small, vertical teeth. Borneo ..... **maai**

13 (6). Cibarium unarmed, with no indication of teeth; alpha about 2 × delta, 2/3 beta or longer. Spermatheca long and tubular. Malaya ..... **anodontis**

Cibarium definitely armed with teeth 14

14 (13). Cibarium heavily sclerotized, comb of about 22 teeth appearing to be deep grooves in heavily sclerotized plate; pharynx slenderly lampglass-shaped with rows of minute denticles at apex; antennal segment 3 exceeding tip of proboscis; alpha and delta both long. Malaya ..... **reidi**

Cibarium not as above, comb of few to many blunt or pointed teeth 15

15 (14). Palpal segment 4 shorter than 2, formula 1–4–2–3–5. Malaya.... **zeylanicus malayae**

Palpal segment 4 longer than 2 16

16 (15). Palpal formula 1–2–4–3–5, segment 4 clearly shorter than 3 17

Palpal formula 1–2–3–4–5, rarely 1–2–(3–4)–5 18

17 (16). Palpus short, barely exceeding antennal segment 4; alpha subequal to beta, delta over 1/2 alpha; mesonotum and pleuron brown; cibarium narrowest at comb, with a proximally convex comb of about 18 blunt teeth; arch strong, distant from comb, at widest part of cibarium. Malaya, Borneo ... **traubi**

Palpus longer, reaching to end of antennal segment 5; alpha shorter than beta, delta about 1/2 alpha; cibarium with about 8 slender pointed teeth in a comb, arch obsolete; antennal segment 3 exceeding proboscis. Coloration generally pale. Malaya ..... **whartoni**

18 (16). Cibarium with an even comb of about 90 fine, hair-like teeth; pigment patch nail-shaped; pharynx lampglass-shaped; antennal segment 3 subequal to proboscis. Head, mesonotum, lower border of pleuron and abdomen heavily infuscated, upper pleuron and coxae pale. Borneo ..... **denticulatus**

Cibarium with less than 50 teeth 19

19 (18). Cibarium with 14 to 16 teeth; pigment patch semicircular with median elongation; antennal segment 3 extending to end of proboscis. Alpha, beta and gamma subequal; delta more than 1/2 alpha. Malaya ..... **iyengari malayensis**

Cibarium with 25 to 30 teeth 20

20 (19). Cibarium with about 25 fishhook-shaped teeth in an even comb; row of small erect teeth below comb; pigment patch beet-shaped; arch strong laterally, weakened in center; antennal segment 3 reaching beyond end of proboscis. Alpha, beta and gamma subequal, delta more than 1/2 alpha. Borneo ..... **maai**

Cibarium with 22 pointed teeth and a single row of 18 erect teeth, area between comb and strong, high arch sclerotized and wrinkled; antennal segment 3 shorter or subequal to proboscis. Alpha longer than beta, delta over 1/2 alpha. Borneo..... **pachystomus**

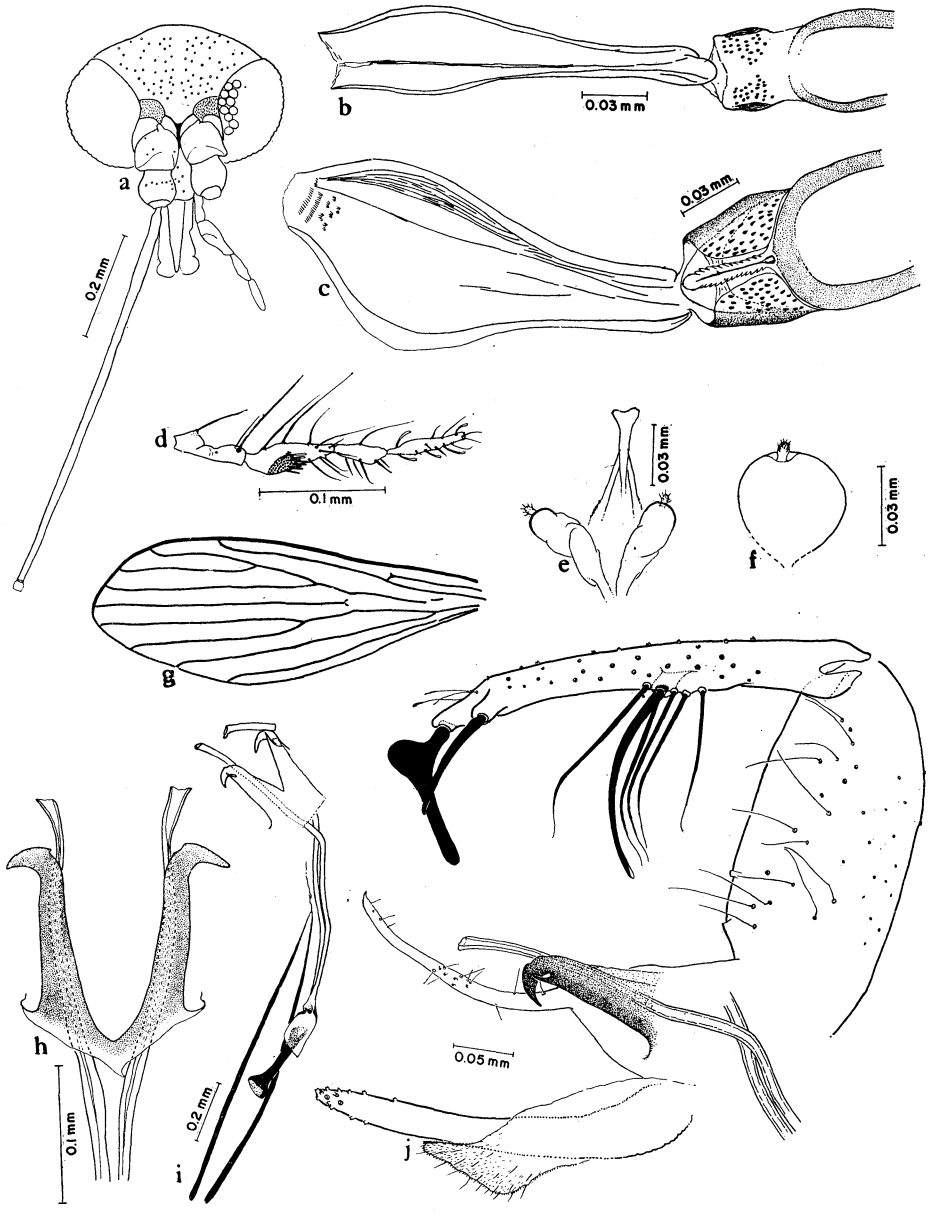

Fig. 1. *Phlebotomus asperulus*, n. sp. a, head, ♂; b, cibarium and pharynx, ♂; c, same, ♀; d, palpus, ♂; e, ♀ spermathecae (shrunken) and furca; f, ♀ spermatheca (drawn in phenol); g, wing, ♂; h, ♂ aedeagus and tip of filaments; i, ♂ genital filaments, pump, aedeagus, and internal abdominal rods; j, ♂ genitalia, inner aspect, side view.

Idiophlebotomus Quate and Fairchild, n. subgen.

Type of subgenus: *Phlebotomus* (*Idiophlebotomus*) *asperulus* Quate and Fairchild, n. sp., by present designation.

Adult characters. Cibarium with number of vertical teeth in 2 triangular patches, less numerous in ♂ than ♀, without horizontal teeth; pharynx unarmed, except may have minute denticles apically. Antennal segment 3 about 3 × or more length of proboscis and greatly exceeding palpus. Palpus short, segment 3 inflated basally and with sunken, concentrated patch of non-spatulate Newstead's scales. Wing moderately broad. Male style very long, with 3 major spines and row of long, non-deciduous hairs; pair of intra-abdominal rods associated with genital pump; cerci long and acutely pointed. Female spermathecae with short, wide ducts.

The closest approach to the many peculiarities shown by this subgenus is found in the African cave-dwelling *P. gigas*, which has been placed in the subgenus *Spelaeophlebotomus* by Theodor (1948). Our species share with *gigas* the presence of the intra-abdominal rods and a somewhat similar wing venation. The male genitalia of *gigas* also has a long style with spines scattered along it, but both their number and position are different. Our species are unique in having a row of long, non-deciduous hairs on the style, in the structure of the cibarium and in the unusual short palpi with the patch of non-spatulate Newstead's scales. The curious terminal spine of *asperulus*, n. sp., is unique, though there is some indication of an incipient swelling on the same structure in *pholetor*, n. sp. The combination of unusual characters shown by the following two species in our opinion warrants the separation from other *Phlebotomus* and the erection of a new subgenus for them.

Phlebotomus (**Idiophlebotomus**) **asperulus** Quate and Fairchild, n. sp. Fig. 1.

Large species with erect hairs on all abdominal tergites, hairs rather evenly distributed on each segment. Color generally brown, pleuron paler than mesonotum and coxae. Coxae very long; ratio of femur, tibia, basitarsus: fore leg = 7 : 11 : 7; mid leg=7 : 13 : 7; hind leg=7 : 15 : 7.

Male. Wing length, holotype 1.9 mm; paratypes 1.8–2.0 mm; venation as figured (fig. 1g), alpha about 1.5× beta, delta less the than 1/2 alpha; wing rather broad. Eyes separated by distance equal to 6 facets; epipharynx 0.13 mm; vertex with hairs scattered and not arranged in rows; clypeus with 6 or 7 hairs; circular patch of microtrichia above antennal socket. Cibarium (fig. 1b) with about 50 vertical teeth in scattered triangular arrangement above arch; arch obsolescent in center; pharynx unarmed except for minute setae at apex, moderately expanded apically. Antenna with pair of simple ascoids on segments 4 to 13, ascoids about 2/3 length of segment 4 and following; segment 3 very long, much longer than proboscis. Palpus (fig. 1d) short, segment 3 enlarged on basal 1/2, with dense cluster of non-spatulate Newstead's scales in depression on mesal face near center, formula 1–2–4–5–3. Genitalia (figs. 1h, i, j) large, style with 3 major spines, 1 apical, 1 subapical and 1 near center, apical spine with marked basal expansion; straight row of 5 long, stiff hairs above base of proximal spine; aedeagus forked, tips strongly hooked; paramere simple, long and slender; genital filaments stout, little more than 3 × length of pump, accompanied within abdomen by pair of long, sclerotized rods.

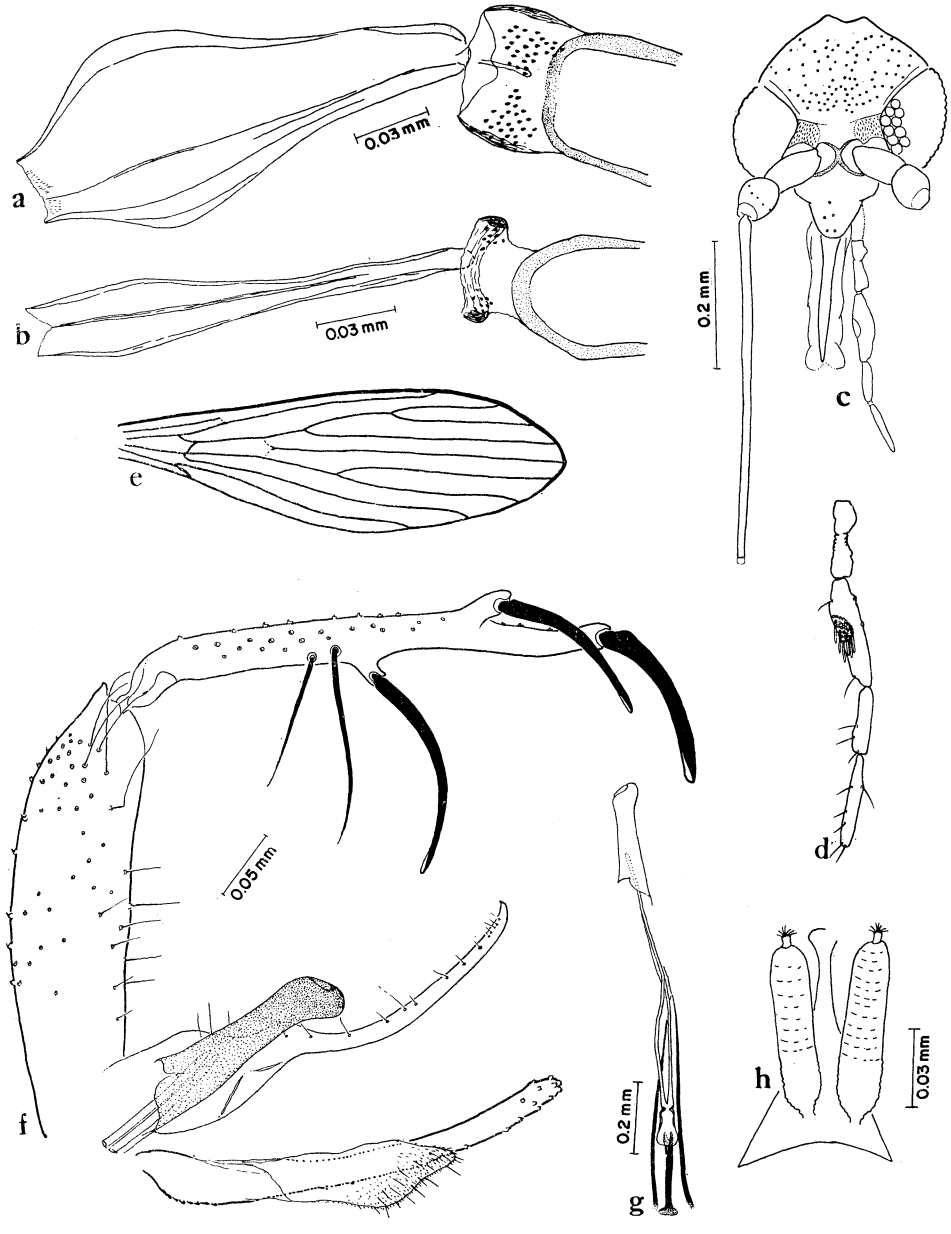

Fig. 2. *Phlebotomus pholetor*, n. sp. a, cibarium and pharynx, ♀; b, same, ♂; c, head, ♀; d, palpus, ♀; e, wing, ♂; f, ♂ genitalia, inner aspect, side view; g, ♂ genital filaments, pump, aedeagus and internal abdominal rods; h, ♀ spermathecae and furca.

Female. Wing length, allotype 2.2 mm; paratypes 2.0–2.5 mm. As male except as follows: Cibarium (fig. 1c) with about 70 vertical teeth arranged in pair of triangular patches on pair of lateral plates, median thickening or rod-like sclerotization with serrate edges between plates; chitinous arch strong; pharynx (fig. 1c) broad, paddle-shaped, well sclerotized, unarmed. Eyes separated by about 7 facets; antenna with pair of simple ascoids on segments 3 to 16. Spermatheca (fig. 1f) globular, smooth-walled, with small hairy apical knob (shrunken spermatheca may appear cylindrical or sausage-shaped, see fig. 1e); structure of ducts indistinct but apparently opening separately into vagina; cerci longer than wide, blunt. No setae on sides of abdominal tergite 8.

Holotype ♂, allotype ♀ (BISHOP 3075), Batu Caves, Kuala Lumpur, Malaya, 11–VIII–59 and 5–IX–59, H. E. McClure. 4 ♂, 3 ♀ paratypes (USNM, BMNH), same locality, 11–VIII–59, 5–IX–59, 7, 8–XII–59.

DISTRIBUTION: Malaya.

Phlebotomus (Idiophlebotomus) pholetor Quate and Fairchild, n. sp. Fig. 2.

Large species with erect hairs on all abdominal tergites, hair not thicker on posterior border of segments. Head, mesonotum, legs and abdomen light brown, pleuron pale. Coxae very long; ratio of femur, tibia, basitarsus: fore leg = 7 : 10 : 6; mid leg = 7 : 12 : 6; hind leg = 8 : 15 : 8.

Male. Wing length, holotype 1.8 mm; paratypes 1.9 mm; venation (fig. 2e) as figured, alpha about 1–1/4 × beta, delta little less than 1/2 alpha. Eyes separated by distance equal to 7 facets; epipharynx 0.1 mm; vertex with hairs scattered and not arranged in definite rows; clypeus with 5 hairs; circular patch of microtrichia above antennal socket. Cibarium (fig. 2b) with about 20 vertical teeth in 2 triangular, lateral patches, no horizontal teeth; pharynx (fig. 2b) unarmed; chitinous arch high, moderately strong. Antenna with pair of simple ascoids on segments 4 to 10, single on 11 to 14, absent on 15 and 16; segment 3 much longer than proboscis. Palpus (fig. 2d) short, with non-spatulate Newstead's scales in dense patch in slight depression near center of mesal face of basally inflated segment 3, formula 1–2–4–5–3. Style (fig. 2f) with 3 major spines, 1 terminal; 2 stiff hairs at base of proximal spine; aedeagus clubbed apically; genital filaments (fig. 2g) about 2.5 × length of pump, accompanied within abdomen by pair of slender, sclerotized rods which are broader than filaments.

Female. Wing length, allotype 2.2 mm. As male except as follows: Eyes separated by distance equal to 6 facets; epipharynx 0.2 mm; cibarium (fig. 2a) with about 50 strong vertical teeth arranged in triangular patch, without lateral plates, with faint median rod; pharynx (fig. 2a) unarmed except for minute denticles apically; antenna with pair of simple ascoids on segments 4 to 15. No setae on sides of abdominal segment 8. Cercus longer than wide, blunt. Spermatheca (fig. 2h) cylindrical, incompletely segmented, faintly wrinkled, ducts very short.

Holotype, ♂ (BISHOP 3076), Gomantong Caves, approx. 30 km S of Sandakan, North Borneo, 23–XI–58, in cave harboring swiftlets and bats, Quate. Allotype, ♀ (BISHOP), 2 ♂, 7 ♀ paratypes (USNM, BMNH), same data as holotype.

DISTRIBUTION: North Borneo.

This species is similar to *asperulus*, but differs in the structure of the cibarium, the

shorter third antennal segment and the male and female genitalia as illustrated. Both species were taken in caves harboring bats and swiftlets and undoubtedly one (or both) is the host, for some engorged females were collected in the caves.

Phlebotomus (Phlebotomus) argentipes Annandale & Brunetti Fig. 3.

Phlebotomus argentipes Annandale and Brunetti, 1908, Rec. Ind. Mus. **2**: 101.

Phlebotomus (Euphlebotomus) argentipes, Theodor, 1948, Bull. Ent. Res. **39**: 98.

Phlebotomus (Phlebotomus) argentipes, Lewis, 1957, Roy. Ent. Soc. London, Proc., ser B, **26**: 165 (Malaya).

Moderate sized species with erect hairs on all abdominal tergites, thickest on posterior border of tergites. Head, mesonotum and abdomen brown, pleuron and coxae pale, legs light brown. Ratio of mid femur, tibia, basitarsus = 5 : 10 : 6, same segments hind leg = 7 : 12 : 4.

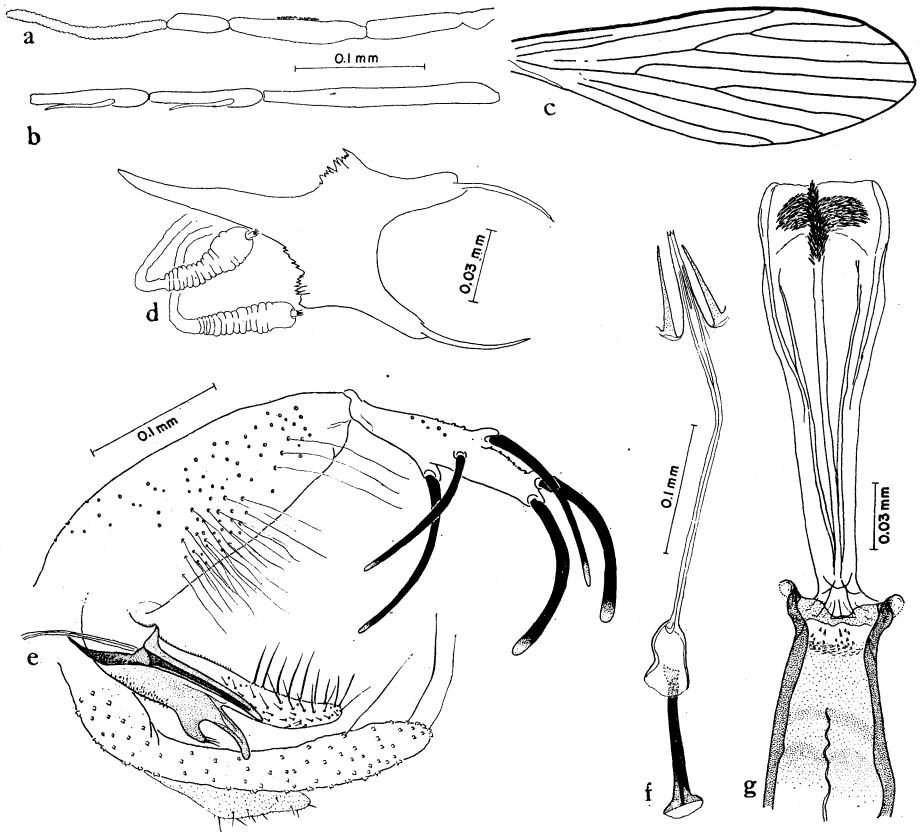

Fig. 3. *Phlebotomus argentipes* Annandale and Brunetti. a, palpus, ♀; b, antennal segments 3–5, ♀; c, wing, ♀; d, ♀ spermathecae and furca; e, ♂ genitalia, inner aspect, side view; f, ♂ genital filaments, pump and aedeagus; g, cibarium and pharynx, ♀.

Male. Wing length 1.8–1.9 mm. Venation as figured (fig. 3c), alpha about 2 × beta and 5 × delta. Eyes separated by 6 facets; epipharynx 0.2 mm. Cibarium without teeth; chitinous arch very weak; spines on pharynx smaller than in ♀. Palpus (fig. 3a) with segments 4 less than 1/2 length of 2 or 3, formula = 1–4–2–3–5, Newstead's scales in dense patch on mesal face of segment 3. Antenna (fig. 3b) with pair of simple ascoids on segments 4 to 15, segment 3 shorter than proboscis. Genitalia (fig. 3e) with 5 spines on style, 2 terminal; parameres forked; aedeagus slender, with pair of spines lying parallel to each side (fig. 3f); filaments (fig. 3f) about 2 × length of pump.

Female. Wing length 2.1 mm. As male except as follows: Eyes separated by 4 or 5 facets; cibarium (fig. 3g) with few scattered, weak teeth; chitinous arch visible but weak; pharynx (fig. 3g) with cluster of spines at apex. Spermatheca (fig. 3d) ovoid, strongly annulate, with long slender ducts, furca with serrations along lateriobasal margins.

Type data: Calcutta, India (Zool. Survey of India).

DISTRIBUTION: India, Ceylon, Thailand, Viet Nam, Malaya, North Borneo.

MALAYA: ♂, ♀, Kuantan, Pahang, 1–VI–56, R. H. Wharton (IMR, Kuala Lumpur); ♂, 2 ♀, Gua 'Che Yatim, King Geo. V Park, Pahang, 17–XII–58, in bat cave, Quate.

NORTH BORNEO: ♀, Kalabakan R., approx. 50 km W of Tawau, 12–XI–58, tree buttress in primary forest, Quate.

Phlebotomus (Phlebotomus) stantoni Newstead

Phlebotomus stantoni Newstead, 1914, Bull. Ent. Res. **5**: 190 (type–Malaya).

Phlebotomus (Anaphlebotomus) stantoni, Theodor, 1948, Bull. Ent. Res. **39**: 99, 108.

We have seen no specimens of this species, but it is similar to *argentipes* and can be separated by the characters given in the key.

DISTRIBUTION: Ceylon, Thailand, Viet Nam, China, Malaya.

Phlebotomus (Sergentomyia) squamipleuris indica Theodor

Phlebotomus squamipleuris, Sinton, 1923, Ind. Jour. Med. Res. **11**: 65 (India); 1931, *ibid.* **19**; 104 (Thailand).

Phlebotomus squamipleuris var. *indica* Theodor, 1931, Bull. Ent. Res. **22**: 470 (India, Turkestan).—Lewis, 1957, Roy. Ent. Soc. London, Proc., ser. B, **26**: 168 (Malaya).

Sergentomyia (Grassomyia) squamipleuris indica Theodor, 1958, Fliegen Pal. Reg., Lief. 201, 9c, Psychodidae–Phlebotominae, p. 47 (India, Turkestan, China).

Distinguished from all other Oriental species by having scale-like setae on the pleura and spermathecae with circles of spines. No material seen by us.

DISTRIBUTION: Turkestan, India, Malaya, Thailand, South China.

Phlebotomus (Sergentomyia) displicatus Quate & Fairchild, n. sp. Fig. 4.

Moderately small species of *nicnic* group (Theodor, 1948) with recumbent hairs on tergites 2–6. Head, median stripe on mesonotum and abdomen light brown, sides of mesonotum, pleuron and legs pale. Ratio of mid femur, tibia, basitarsus=5 : 6 : 3.

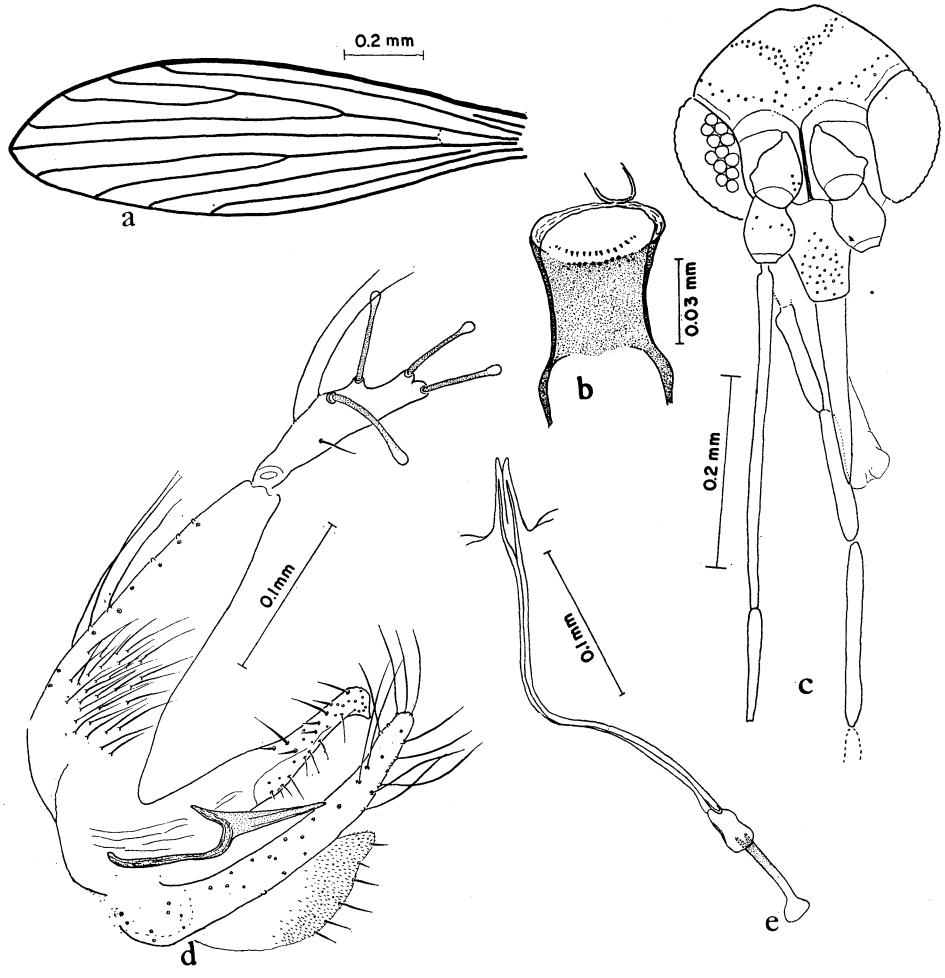

Fig. 4. *Phlebotomus displicatus*, n. sp., ♂. a, wing; b, cibarium; c, head; d, genitalia, inner aspect, side view; e, genital filaments, pump, aedeagus.

Male. Wing length, holotype 1.6 mm; paratypes, 1.5–1.6 mm; venation (fig. 4a) as figured; alpha subequal to beta, about 2 × delta. Eyes separated by distance equal to 9 facets; epipharynx 0.2 mm. Cibarium (fig. 4b) with about 15 vertical and double row of 20 erect teeth; no pigment patch, but whole area between cibarial comb and chitinous arch darkened; pharynx unarmed except for several rows of minute setae, lampglass-shaped. Antenna with only single ascoid visible on segments 4 to 8 (remaining segments lacking). Palpal formula 1–2–3–4–5. Genitalia (fig. 4d) with 4 spines on style, most proximal at center of segment; coxite with patch of setae on inner face near base; filaments (fig. 4e) little more than 3 × length of pump.

Female. Unknown.

Holotype, ♂ (BISHOP 3077), Kalabakan R., approx. 50 km W of Tawau, British North Borneo, 11–XI–58, tree buttress, Quate. 3 ♂ paratypes (USNM), same data as allotype.

DISTRIBUTION: Borneo.

This species is closely allied to *nicnic* Banks, but differs in that the pigment patch of *nicnic* is T-shaped and absent in *displicatus* and the third antennal segment is short in *nicnic*, about as long as the fourth and fifth combined, while the third segment is longer in *displicatus*. The cibarial teeth seem to differ, also, but this cannot be clearly ascertained from Manalang's (1930) redescription, although it appears that the cibarial teeth of *nicnic* may be more numerous than in *displicatus*.

Phlebotomus (Sergentomyia) whartoni Lewis, 1957, Roy. Ent. Soc. Lond., Proc., ser. B, **26**: 165.

From our single specimen we can add little to Lewis' description (*l. c.*), except to note that the mesonotum and abdomen are brown and the legs pale.

DISTRIBUTION: Malaya.

MALAYA: 1 ♂, Gua 'Che Yatim, King Geo. V Pk., Pahang, 17–XII–58, in bat cave, Quate.

Phlebotomus (Sergentomyia) brevinervis Quate and Fairchild, n. sp. Fig. 5 a–d.

Small species with recumbent hairs on tergites 2–6. Head, mesonotum, abdomen light brown; pleuron and legs pale. Femora and tibiae of all legs subequal in length.

Male. Wing length, 1.1 mm; venation (fig. 5b) as figured, alpha short and delta very short or negative. Eyes separated by distance equal to 10 facets; epipharynx 0.14 mm. Cibarium (fig. 5c) with 14 short, vertical teeth and irregular row of 13 erect teeth, no pigment patch but area between arch and teeth lightly pigmented; chitinous arch obsolescent; pharynx rather slender, unarmed. Palpus extending to antennal segment 7, formula 1–2–3–4–5, Newstead's scales not visible. Antenna with segment 3 very short, not exceeding tip of proboscis, less than 2 × length of 4; single ascoids on segments 4 to 9, remaining segments lacking. Genitalia (fig. 5a) with parameres little longer than lateral lobes, genital filaments about 3 × length of pump, style with all spines apical, ventral seta proximal to spines.

Female. Unknown.

Holotype ♂ (BISHOP 3078), Ranau, North Borneo, 16–X–58, tree buttress, Quate. Paratypes (USNM), 2 ♂, same locality, 3–X–58 and 8–XI–58.

DISTRIBUTION: North Borneo.

The narrow wing with the short alpha and short or negative delta and the short third antennal segment are the most obvious characters which separated *brevinervis* from other known Indo-Malayan *Phlebotomus*. This species is very close to *P. babu* Annandale (India; see Sinton, 1933, Pl. XXIV), but males of *brevinervis* have a more slender aedeagus and longer parameres than do *babu* males. Also, *brevinervis* males lack the small cibarial pigment patch found in *babu* and have about four less vertical and erect teeth. Females of the two species might show more distinct differences.

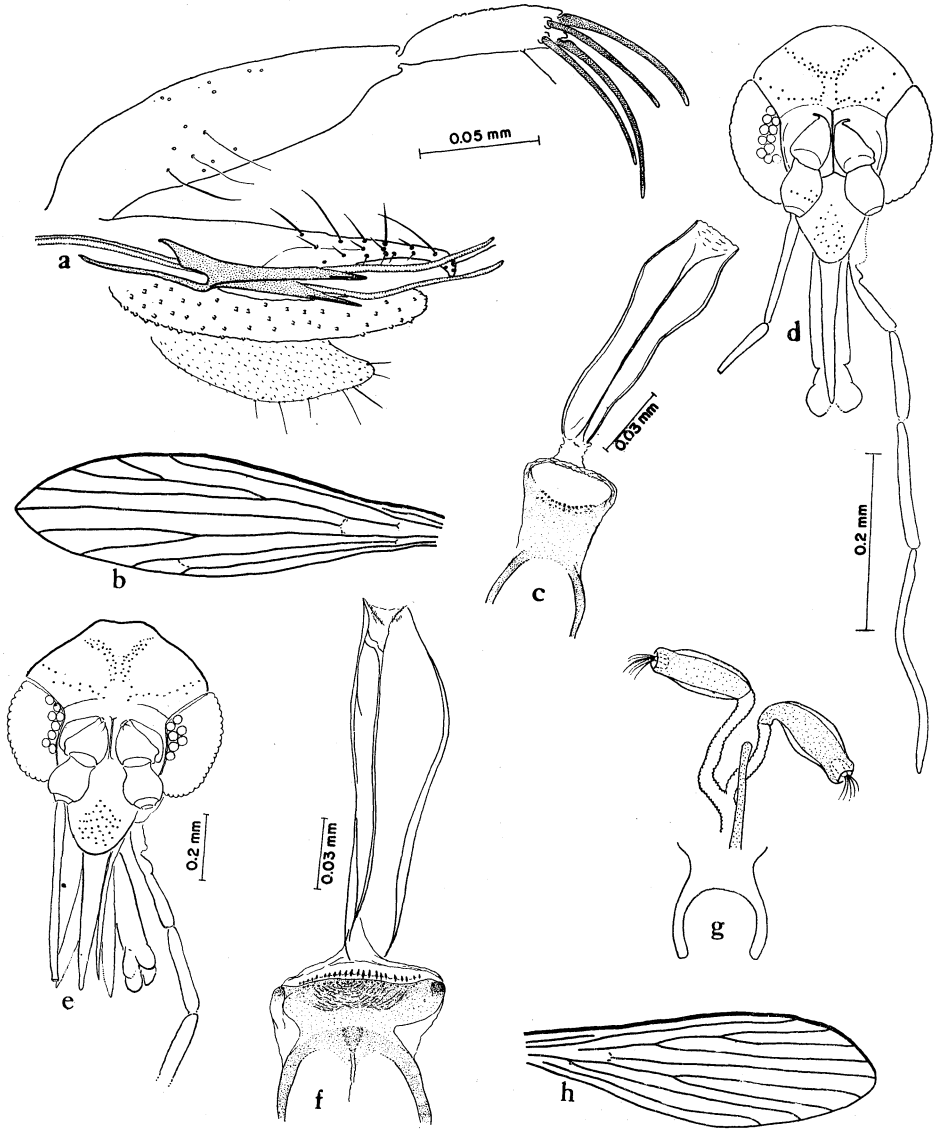

Fig. 5 a–d. *Phlebotomus brevinervis*, n. sp., ♂. a, genitalia, inner aspect, side view; b, wing; c, cibarium and pharynx; d, head. e–h. *Phlebotomus pachystomus*, n. sp., ♀. e, head; f, cibarium and pharynx; g, spermathecae and furca; h, wing.

Phlebotomus (Sergentomyia) pachystomus Quate and Fairchild, n. sp. Fig. 5 e–h.

Moderate sized species with recumbent hairs on tergites 2–6. Head, median stripe of mesonotum brown, pleuron and legs pale. Ratio of mid femur, tibia and basitarsus = 6 : 8 : 4; fore femur and tibia equal in length.

Female. Wing length, holotype 1.5 mm, paratypes 1.5–1.8 mm; venation (fig. 5h) as figured; alpha about 1.5 × delta, beta and delta subequal. Eyes separated by distance equal to 9 facets; proboscis unusually thick and heavy, epipharnyx 0.2 mm. Cibarium (fig. 5f) with 22 pointed teeth and close below a row of 18 erect teeth; arch high and strong; area between arch and comb sclerotized and wrinkled; pharynx strongly ridged, rather broad posteriorly. Palpus with patch of Newstead's scales on mesal face 1/5 segment length from base, patch extends over 1/5 of segment, 5 very long, about 2× length of 4, formula 1–2–3–4–5. Antenna with segment 3 not exceeding tip of proboscis, ascoids paired on segments 4–10, apparently single on remainder, base of ascoid with small spur, tip not exceeding tip of respective segment. Tergite 8 with patch of hairs laterally. Spermatheca (fig. 5g) double walled, ovoid, smooth, terminal button sunk in cup-shaped depression; cerci about 2× long as wide, blunt.

Male. Unknown.

Holotype, ♀ (BISHOP 3079), Kalabakan R., approx. 50 km W of Tawau, North Borneo, 11–XI–58, Quate. Paratypes (USNM): 2 ♀, same data as holotype; 1 ♀, Ranau, North Borneo, 16–X–58, tree buttress, Quate.

DISTRIBUTION: North Borneo.

Phlebotomus (Sergentomyia) traubi Lewis, 1957, Roy. Ent. Soc. London, Proc., ser B, **26**: 169 (Selangor, Malaya; BMNH).

The whole insect is brownish, except the pale coxal bases and legs. Our material agrees well with Lewis' description and figures, except the spermatheca, examined in phenol before mounting, shows more definite rings of small spines than indicated by Lewis and our Malayan specimen has a slightly longer delta and a faint nail-shaped pigment patch.

MALAYA: 1 ♀, Terenggan, Pahang, 18–XII–58, Quate.

NORTH BORNEO: 1 ♀, Kalabakan R., 50 km W of Tawau, 12–XI–58, primary dipterocarp forest, Quate.

DISTRIBUTION: Malaya, North Borneo.

Phlebotomus (Sergentomyia) denticulatus Quate and Fairchild, n. sp. Fig. 6.

Medium sized species with recumbent hairs on tergites 2–6. Head, mesonotum, lower part of pleuron, and abdomen infuscate, upper pleuron and legs pale. Ratio of mid femur, tibia, basitarsus=5 : 6 : 3.

Female. Wing length, holotype 1.6 mm, paratypes 1.5–17 mm; venation (fig. 6d) as figured; beta 2/3 to 1/2 alpha, delta about 2/3 alpha. Eyes widely separated by distance equal to 12–15 facets; epipharynx 0.2 mm. Cibarium (fig. 6a) broad, with comb of about 90 fine hair-like, horizontal teeth and about 20 vertical teeth; pigment patch nail-shaped; arch obsolescent in center; pharynx wrinkled posteriorly, but unarmed; palpus with number of Newstead's scales on inner face of basal 1/3 of segment 3, formula 1–2–3–4–5. Antenna (fig. 6e) with pair of simple ascoids on segments 4 to 13, not visible on remainder, segment 3 extending to tip of proboscis. Spermatheca (fig. 6c) simple, ovoid, double walled, without annulations. A few setae on sides of tergite 8.

Male. Wing length, allotype 1.8 mm, paratypes 1.3–1.8 mm. As female except as follows: Eyes separated by 10–12 facets; cibarium (fig. 6b) with comb of 19 fine teeth, no

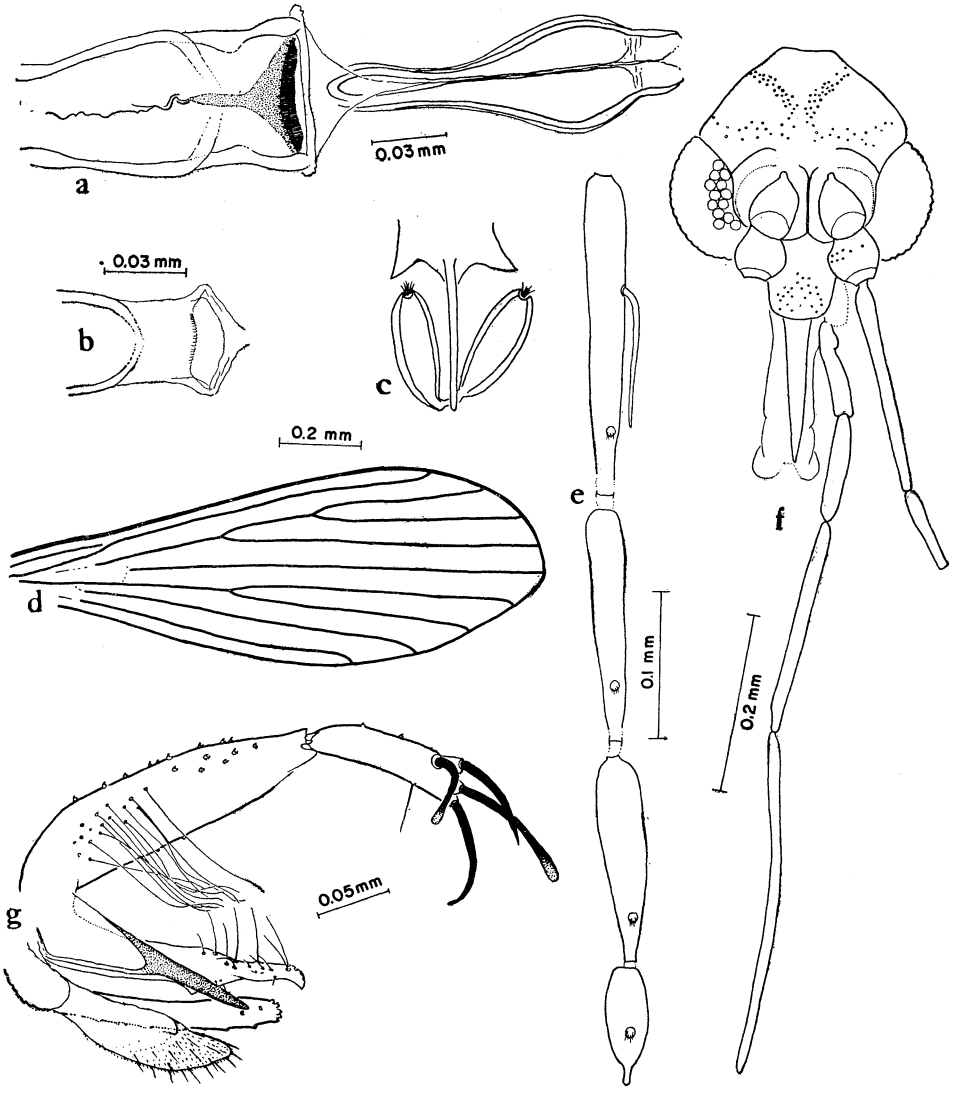

Fig. 6. *Phlebotomus denticulatus*, n. sp. a, cibarium and pharynx, ♀; b, cibarium, ♂; c, ♀ spermathecae and furca; d, wing, ♀; e, antennal segments 13–16, ♀; f, head, ♀; g, ♂ genitalia, inner aspect, side view.

pigment patch visible; pharynx more slender. Antenna with single, simple ascoids on segments 4 to 15. Beta 3/4 to subequal to alpha. Genitalia (fig. 6g) of *minutus* type; style with 2 terminal and 2 subterminal spines, seta distad to most basal spine; aedeagus slender, simple; filaments 3× length of pump.

Holotype, ♀ (Bishop 3080), Gomantong Caves, approx. 30 km S of Sandakan, North Borneo, 26–XI–58, in cave, Quate; allotype, ♂, Ranau, British North Borneo, 8–XI–58, tree buttress, Quate. Paratypes (USNM, BMNH), 2 ♀, same data as holotype; 4 ♀, 3 ♂,

same locality as allotype, 3, 6, 16–X, 8–XI–58, Quate; 2 ♀, Kalabakan R., approx. 50 km W of Tawau, North Borneo, 12–XI–58, tree buttress in primary forest, Quate.

DISTRIBUTION: North Borneo.

This species is similar to *P. manganus* Manalang from the Philippines in a number of respects, but differs in the shape of the pharynx and in wing venation. The female cibarium appears nearly identical to *englishi* Tonnoir (**1935**: 144) and *englishi moresbyi* Fairchild (**1952**: 201), but those forms have a characteristic short third antennal segment unlike this species. *P. dolichobyssus* Fairchild (**1952**: 202) is also similar, but has a greater number (about 125) of cibarial teeth and very much longer genital filaments. The fine-toothed structure of the female cibarium and small teeth of the male cibarium differ from other Borneo members of the *minutus* group.

Phlebotomus (Sergentomyia) maai Quate and Fairchild, n. sp. Fig. 7.

Medium sized species with recumbent hairs on tergites 2–6. Head, median part of mesonotum and abdomen brown, lateral part of pleuron and coxae light brown, upper pleuron and legs pale. Ratio of mid femur, tibia, basitarsus = 7 : 8 : 4, fore femur longer than tibia.

Female. Wing length, holotype 1.9 mm; venation (fig. 7d) as figured; alpha usually little longer than beta, about 1.3 × delta but quite variable. Eyes separated by distance equal to 8 facets; epipharynx 0.2 mm. Cibarium (fig. 7c) with about 25 fishhook-shaped teeth in even comb, 14 erect teeth below comb, center 4 larger than lateral ones; pigment patch beet-shaped; chitinous arch strong laterally, but weakened in center; pharynx unarmed. Newstead's scales on mesal face of palpal segment 3 on basal 1/3, formula 1–2–3–4–5. Antennal segment 3 reaching beyond end of proboscis, ascoids single on segments 3 to 12 (antenna broken beyond), very short, less than 1/4 length of segments. Spermatheca (fig. 7e) smooth and ovoid, with small, sunken, terminal tuft of setae.

Male. Wing length, allotype 1.7 mm. As female except as follows: Alpha sometimes shorter than beta, but usually subequal; genitalia darker in color than abdomen; eyes separated by 9 facet diameters; cibarium (fig. 7b) with 12 to 15 small vertical teeth apparently not fishhook-shaped and 8 erect teeth; no visible pigment patch. Genitalia (fig. 7f) of *minutus* type; style with 2 apical and 2 subapical spines; ventral seta based of subapical spine; setae on base of coxite; parameres little longer than lateral lobes; aedeagus slender; genital filaments (fig. 7g) long, about 4× length of pump.

Holotype, ♀ and allotype, ♂ (BISHOP 3081), 5 ♀ and 5 ♂ paratypes, Tawau, North Borneo, 19–XI–58, sweeping on beach at dusk, Maa & Quate.

DISTRIBUTION: North Borneo.

It is with pleasure we dedicate this species to Prof. Tsing-chao Maa, who was a wise and congenial companion with one of us (L. W. Q.) in Borneo.

Phlebotomus (Sergentomyia) zeylanicus malayae Lewis, 1957, Roy. Ent. Soc. London, Proc., ser. B, **26**: 166 (Malaya; BMNH).

DISTRIBUTION: Malaya.

This species seems near *maai*, but differs in having fewer cibarial teeth. Also, the re-

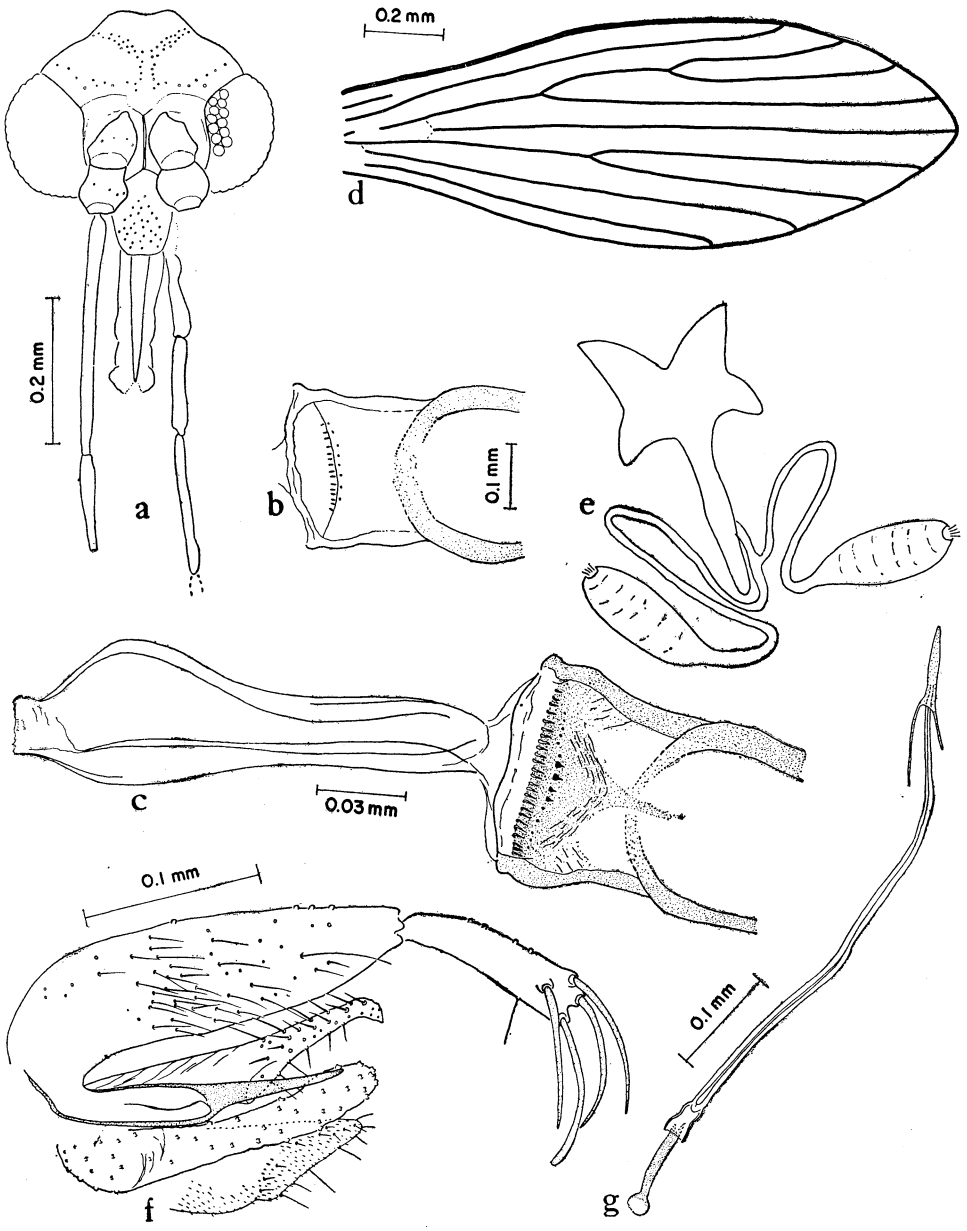

Fig. 7. *Phlebotomus maai*, n. sp. a, head, ♂; b, cibarium, ♂; c, cibarium and pharynx, ♀; d, wing, ♀; e, ♀ spermathecae and furca; f, ♂ genitalia, inner aspect, side view; g, ♂ genital filaments, pump and aedeagus.

lative palpal lengths differ in the two species with the fourth segment being shorter than the second in *malayae* and longer in *maai*. The male of *malayae* is unknown. We have seen no specimens of this species.

Phlebotomus (Sergentomyia) iyengari malayensis Theodor

Phlebotomus iyengari var. *malayensis* Theodor, 1938, Ind. Jour. Med. Res. **26**: 264 (Malaya).—Lewis, 1957, Roy. Ent. Soc. London, Proc., ser. B, **26**: 168 (Malaya).

We have seen no specimens of this species and it is placed in the key on the basis of the description.

DISTRIBUTION: Malaya.

Phlebotomus (Sergentomyia) reidi, Lewis, 1957, Roy. Ent. Soc. London, Proc., ser. B, **26**: 169 (Selangor, Malaya; BMNH).

Our female specimens agree well with the original description of *reidi*, except that they do not show the apical constriction of the spermatheca figured by Lewis (*l. c.*). However, the author states the spermatheca was twisted and this may have produced the constriction.

DISTRIBUTION: Malaya.

MALAYA: 3 ♀, King Geo. V. Park, Pahang, Gua 'Che Yatim, 16-XII-58, in bat cave, Quate.

Phlebotomus (Sergentomyia) anodontis Quate & Fairchild, n. sp. Fig. 8.

Small species with recumbent hairs on tergites 2 to 6. Head, mesonotum and abdomen brown, pleuron and coxae pale. Ratio of mid femur, tibia, basitarsus=6 : 8 : 4.

Female. Wing length, holotype 1.7 mm; paratypes 1.5–1.8 mm; venation (figs. 8g, f) as figured, but alpha variable from 2/3 of to little more than beta, one specimen may show this variation in its 2 wings; alpha about 2× delta with less variation in this relation than above. Eyes separated by distance equal to 8 facets; epipharynx 0.16 mm. Cibarium (fig. 8b) unarmed, but with spine-like projections from fold in membrane above sclerotized part and with median projection over which is inverted V-shaped bar; arch strong, but sharply interrupted at center; pharynx (fig. 8b) slender, unarmed. Palpus with Newstead's scales on basal 1/2 of inner face of segment 3, formula 1–2–3–4–5. Antenna with segment 3 exceeding tip of proboscis, pair of simple ascoids on segments 3 to 13, apparently single on 14, 15, 16, ascoids about 1/3 length of segment 3; segments 14, 15 and 16 shorter and thicker than preceding segments, with number of setose pits, 16 with slender apiculus. Tergite 8 with lateral patch of hairs. Spermatheca (figs. 8d, e) long and tubular, no differentiation between spermatheca and duct until point of junction of individual duct, apex with thick, hairy, sunken knob, several annulations below knob.

Male. Wing length, allotype 1.25 mm; paratypes 1.3–1.5 mm. As female except as follows: Cibarium structure similar but much more lightly sclerotized and smaller; antenna with very short, single ascoids. Wing with alpha-beta ratio less variable, alpha shorter than beta, delta 1/3 to 1/2 alpha. Genitalia (fig. 8h) as figured, style with 4 spines, 2 apical, 1 subapical, 1 one-fourth distance from apex, seta proximal of all spines; aedeagus slender, separated apically; paramere ending in sharp beak, much shorter than lateral lobe; filaments (fig. 8i) 4× length of pump.

Holotype ♀, allotype ♂ (BISHOP 3082), Batu Caves, Kuala Lumpur, Malaya, 11–VIII–59 and 5–IX–59, H. E. McClure. Paratypes (USNM, BMNH): 11 ♀, same as holotype;

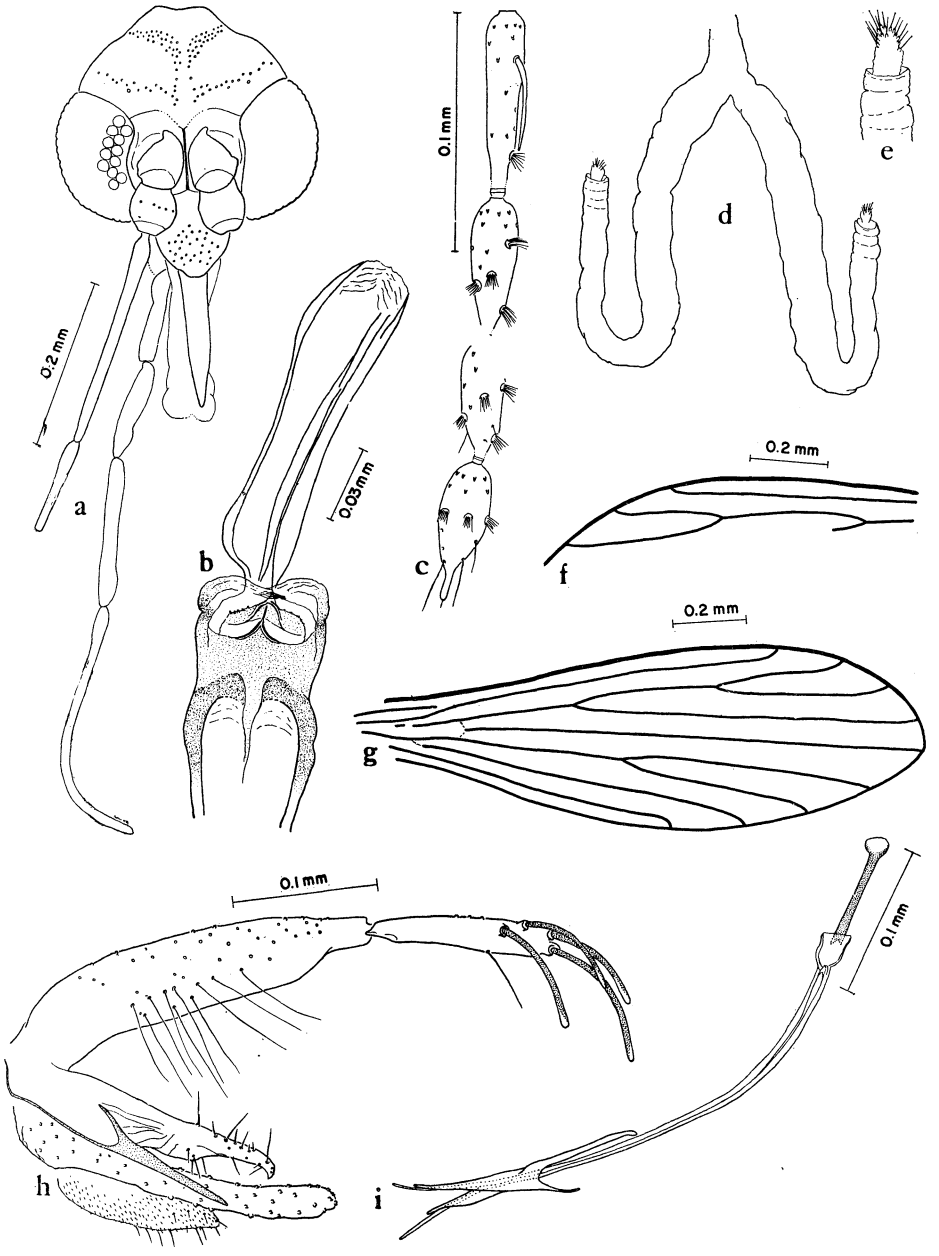

Fig. 8. *Phlebotomus anodontis*, n. sp. a, head, ♀; b, cibarium and pharynx, ♀; c, antennal segments 13–16, ♀; d, ♀ spermathecae and ducts; e, ♀ spermatheca; f, wing, ♀, showing, a variation of alpha and beta; g, wing, ♀; h, ♂ genitalia, inner aspect, side view; i, ♂ genital filaments, pump and aedeagus.

3 ♂, 11 ♀, same as allotype; 8 ♀, same locality, 7, 8, 9, 11-XII-59.

DISTRIBUTION: Malaya.

This species is readily distinguished by the unarmed cibarium and the tubular female spermathecae.

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